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ABSTRACT

The student traceback model is described and is used to demonstrate various concepts relative to institutional research methodology. The methodology of the problem-solving institutional researcher includes a wide spectrum of how-to's: how to anticipate issues in higher education and estimate their practical institutional impact; how to develop the tools to solve problems; and how to present decision-influencing solutions. For any distribution of students in a session, the student traceback model yields the distribution (academic program parameters and student characteristics) in the last session. The model has practical institutional research application in resource reallocation, curriculum planning, and academic departmental decision-making. The student traceback model is used to demonstrate three different aspects of institutional research methodology: (1) evolution of the conceptual model; (2) identification of model capabilities and feasible applications; and (3) practical application of the model to specific campus problems. The application of the model at the University of Calgary to the specific problems of identification of part-time students, estimation of the resource implications of proposed changes to student academic programs, and separation of students into those expected to move to new programs and those expected to remain with the old program are described. (Author/SC)

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STUDENT TRACEBACK MODEL: AN ESSAY ON INSTITUTIONAL RESEARCH METHODOLOGY

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ABSTRACT

The methodology of the problem-solving institutional researcher includes a wide spectrum of how-to's; how to anticipate issues in higher education and to estimate their practical institutional impact, how to develop the tools to solve problems and how to present decision influencing solutions. For any distribution of students in a session, the student traceback model yields the distribution (academic program parameters and student characteristics) in the last session. The model has practical institutional research application in resource reallocation, curriculum planning and academic departmental decision making. Three different aspects of methodology are illustrated by the student traceback model: the conceptual model is evolved, model capabilities and feasible applications are identified and, finally, several practical applications to specific campus problems are demonstrated.

STUDENT TRACEBACK MODEL: AN ESSAY ON INSTITUTIONAL RESEARCH METHODOLOGY

The student traceback model (STM) is an analytical construct which we will treat as both a conceptual model and as practical computer software. Its many subtle properties make the flexible STM an ideal candidate for use in demonstrations of institutional research methodology. Given the state of our art, many aspects of institutional research are most readily presented in the context of an example. Thus, this essay employs several such illustrations to convey notions from the wide spectrum of institutional research methodology. These examples include the evolution of the conceptual model, the development of STM capabilities and the identification of its feasible applications and, finally, several model applications to specific campus problems.

This paper has two purposes. One is to present the practically useful STM. Another is to convey something of what we learned about institutional research methodology through our experience in "building" and applying the model. Institutional research is normally viewed as a profession and an applied field of study. The paramount importance of the practicality of institutional research results is unquestioned and, of course, does not imply that it is a discipline devoid of a theoretical basis. Yet, the old nemeses of institutional research, the absence of agreed definitions and the lack of an unambiguous technical language still gravely hinder generalized discussion of methodology and, instead, tend to reinforce the pragmatic view that institutional research results must be expressed in the concrete context of a known institution, system or process. Still, the essay must go on, and to

that end, let us offer a few definitions which may serve for this current discussion. Consider the following:

1. Institutional research is the study and analysis of the environments, operations and processes of institutions of higher education in order to obtain information to support decision making in higher education.
2. Institutional research methodology is the collectivity of methods, principles and rules along with their application procedures used in institutional research.
3. The theory of institutional research would be a generalized basis which would be common to the methodology and would provide a coherent group of generalized principles which explain the methodology.

In an effort to tiptoe around the nemeses, let us suggest that for current purposes the important point proposed by the three definitions is that on a scale which goes from particular to general, methodology is midway between. Methodology may be freed from a particular institutional context, but it need not be shown to be a special case of some generalized theory.

Each activity of institutional researchers adds to the list of elements of the methodology and, hence, to the difficulty of reaching an agreed definition of the field and to the complexity of any realization of a theory. There are many activities in this class. Institutional researchers study current issues in higher education, develop systems and procedures, support all aspects of institutional planning from setting goals to program development, to program review, to budgeting and program evaluation, provide information for collective bargaining and many other activities. Institutional

researchers also develop analytical tools and techniques, teach institutional research and practice in diverse higher education establishments around the world. Some of the familiar ideas which demonstrate the essence of institutional research methodology include the induced course load matrix (ICLM), student flow model (SFM), the program classification structure (PCS), decision paradigms, fundamental ideas from closely related fields, such as information systems and statistics. These are all examples of notions which have sufficient generality to be taken as elements of institutional research methodology.

The value of many examples from institutional research methodology, like the student traceback model, are practical yet subtle. While one can describe the tool in detail and exhaustively illustrate its applications, the ultimate usefulness of all tools depends on the skill in the hand and mind of the user. Sometimes analytical problems are solved by straightforward and even elegant solutions. Yet, often the real insight to a solution comes only after long disorganized plotting, struggle--and the elegant solution only becomes evident with the benefit hindsight. Efforts to generalize institutional research experience, to make communications easier and more effective and to provide a basis for further theoretical research on questions of relationships, important variables, proxies are all important to the practitioner. As in any profession, we don't expect to find the ultimate formula which allows full automation in all circumstances. Nonetheless, each new addition to the methodology provides the practitioner with one more tool to enhance his or her problem solving skills.

Better institutional research skills are continually needed to overcome common practical problems such as those which arise when data are not

available in the most convenient form, when it is too costly in time or other resources to put data in the necessary form and when alternative data are not known. There are many examples of the important project which must be given low priority because the data, say, a time series of comparable data points, are not available and neither alternative data nor known methodologies are practical. Typically, these institutional research problems have aspects which are peculiar to the institution, system or process. What is needed are the skills and insight generators which allow the experienced professional to fashion a particular solution. We think such skills are enhanced by study and research on the methodology of institutional research.

STUDENT TRACEBACK MODEL AS DUAL OF STUDENT FLOW MODEL

Application of the notion of duality in other fields often suggests similarities and analogies which greatly expand theoretical and practical aspects of those fields. Since we are here attempting to expand on our understanding of the methodology, and not the theory of institutional research, we will proceed more by demonstration and illustration than by appeal to first principles. The idea we will try to exploit is that of dual concepts or the property of certain statements to be equally true when appropriate dual concepts are interchanged.

The essential principle of the student flow model is the progression of students through the successive stages of their programs. Students flow from the present to the future. The sort of question we ask is, does a useful construct emerge if one considers the "flow" from the past to the future--or, alternatively, what emerges if one focuses not on the future distribution of students, but on their source--"where" they came from? This leads us,

more formally, to try to define the dual[1] of the SFM. The simplest description of the SFM is as follows. For any distribution of students in a session, the SFM yields a distribution in the *next* session. Since we know we seek the dual of SFM, we know the name of the model will change by substituting "reverse flow" or some equivalent for "flow". Our experience using model software suggested the word "traceback". The change in direction insinuates the past as dual to the future. Hence, the definition of STM would be: for any distribution of students in a session, the STM yields the distribution in the *last* session. Initially, we do not want to judge the pragmatic value of the new model, only its plausibility.

Let us now move to consider the differences in these dual models to see whether additional features will suggest practical methodological ideas. The SFM is essentially an aggregate model. That is, since one is projecting future enrolment distributions, the model does not treat each individual student, but (typically), the process is a cohort survival method which averages all factors and yields student numbers in various categories--student distributions. On the other hand, the dual STM inherently deals with individual students whose institutional histories are available. Hence, the sources of any group of students can be traced for as many sessions in the past as the longitudinal data are available.

Are there other inherent features of the STM? Proceeding as before, we note that an important use of the SFM is to provide input to the appropriate induced course load matrix (ICLM) which, in turn, allows projections

of instructional loads by academic disciplines. The pertinent STM attribute suggested by duality is one which operates on student distributions on the outcomes side of the ICLM, that is, students enrolled in specific courses or categories of courses. Students in these courses can be traced back to source(s) of interest to the particular application. This property of the STM, essentially the mathematical equivalent of inversion of the ICLM, is simply realized in practical terms. As it turns out, the student record system will allow for even more information in a more straightforward fashion. For each student registered in a course, one can trace back through student records along the historical dimensions most appropriate to the study or project.

To summarize first in the dual language format, we have:

SFM - current student characteristics yield projected ICLM input;

STM - current ICLM output yields historical student characteristics.

Or, to elaborate the earlier definition: for any specific group of students in a session, the STM determines academic program parameters and student characteristics which describe the group in a previous session. The brief analysis above has begun to fill out the sketchy picture of the STM. The STM is disaggregated, deals with individual students and not averages of cohorts, it answers questions about the "source" of students, not about eventual distributions (projection) of students, whereas the SFM is student-in-student-academic-program centered, the STM deals equally well with courses-in-disciplines. Rather than pull on this particular thread to flesh out the features of the model inherent because of its duality relationship with SFM, let us broaden the discussion. In the following section we will attempt to deduce as well as model features, those plausible areas of applications of software with STM characteristics.

DUAL CONCEPTS, MODEL FEATURES AND PLAUSIBLE APPLICATIONS

Dual concepts, like source/projection, individual/cohort, course-in-discipline/student-in-program suggest the outlines of practical problems for which the dual model is useful. Figure 1 samples such notions and attempts to associate plausible areas of model application with sets of dual concepts. The comparison is, of course, between the SFM and its dual, STM, but in Figure 1 and in this discussion, we will not rehearse the already well-known implications of the SFM suggested by any attribute. Since the practical ramifications for the model because of its dual features and plausible areas of application are often reasonably self-evident, we will attempt to limit our comments to pointing out features which may lead to further interesting analysis or insights.

Figure 1 is a useful summary of associations and was compiled as much by brainstorming techniques as logical deduction. Remember, the value of the table is not only its completed form, but also lies in the ideas its preparation generates on STM and, more generally, on institutional research methodology. Let us demonstrate by playing a few rounds of what we will call the duality game.

Source/Projection

This set of dual concepts has already been introduced and the reader probably has a good feel for the implications for model features and plausible applications. Nonetheless, let us see whether there is more that can be squeezed out of this pair. Do not expect a unique set of properties to be associated with a set of dual concepts because the various dual concepts are, of course, closely related. Some of the deduced model features and applications may, in turn, suggest dual concepts. For example, flow and traceback

Figure 1

DUAL CONCEPT ASSOCIATIONS

DUAL CONCEPTS	POSSIBLE PRACTICAL MODEL APPLICATIONS
Source / Projection	- student characteristics are important in estimating ICLM element stability - student characteristics are useful in SFM transition probability estimates
Discipline / Student	- reverse course flow is an important concept in curriculum planning
Individual / Cohort	- emphasis on individual student allows study to focus on student characteristics available in the data base--including grades. admission information
Synthesis / Analysis	- build ICLM, build SFM, as opposed to using ICLM and SFM to show distributions
Costs / Resource Requirements	- costs are typically determined "by student" thus the traceback feature allows for historical accumulation of costs by student category
Reallocation / Allocation	- this is a variation on discipline/student. At very high levels in the organizational structure allocation is often based on student numbers in categories. The problem of reallocation over time within a school or department typically is more sensitive to trends in course enrolment patterns by student types
Program Review / Program Development	- implied by dual retrospective and future focuses

suggest future and past as well as projection and source. To paraphrase McLuhan, and with apologies to Stengel and Steinbrenner, the game is the message.

The focus on "source" suggests that attention may be directed at any combination of data elements in the student record system. Thus, the game may advance by consideration of applications for which analysis of student characteristics is relevant. This process may also suggest certain model features. For example, STM software ought to be able to retrieve from the institutional student data base, and have the capacity to format outputs conveniently. Let us consider a familiar and continuing problem in institutional research--the care and feeding of the ICLM. Most offices have experience in trying to minimize the impact of the instability of ICLM elements. The numerical value of the elements depends on the characteristics of the appropriate subset of students. Knowledge of trends in these characteristics of specific students may provide important information on likely changes in element values. Thus, the STM software may prove handy as one of the aids in determining ICLM element values. In the next section, we will show how the software was used in our office to adjust ICLM elements in response to a "what if" planning question asked by a dean.

Another example of the same sort involves the elements of the transition probability matrix used in most SFM's. The likelihood of a cohort to pass from one state to another in a time period is dependent on student characteristics, and the changes in the transition probabilities are dependent on trends in the pertinent characteristics of the relevant students.

Discipline/Student

This set of dual concepts, associated with the columns and rows of the ICLM, suggests the usefulness of STM based on its relationship to

disciplines and, hence (among other things), to the curriculum. The STM is also a reverse course flow model. That is, for any group of students in a course in a particular session, the reverse course flow model will provide the courses taken in the (or any or all) previous session by these students. Thus, while the SFM is used to predict enrolment, the STM is useful in estimating the academic profile of the students in the course now, in the past, or in the future. As an example, consider the following familiar scene in the first day of many courses. The professor asks students to fill out a questionnaire requesting statistical data on students to give the professor an appreciation of the academic background of the class. This information could be suitably, flexibly compiled for any class by the STM. It is perhaps a future application.

Individual/Cohort

Disaggregation to the level of the individual student implies dependency on detailed information, thus the STM, more than SFM, is limited by the capacities of the institutional student/course/timetable data base. Disaggregation also suggests that problems which focus on courses, disciplines or departments are more likely to be amenable to STM application whereas the SFM is likely to be used more effectively at the school, institutional or system level. In some circumstances, to suggest another dual pair, reallocation may indicate STM whereas allocation, especially at high levels in the organizational structure, may infer SFM. In any case, STM software is likely to be more sophisticated and its demands on the data base harder to meet. The most obvious requirements on the data base are consistent records readable over time. These ideas, which emphasize the nature of model data requirements, in turn, suggest the dual set longitudinal/cross-sectional. The STM allows

analysis of the same individuals (characteristics) through time, the SFM develops average parameters by cross-sectional analysis of cohorts at a point in time.

We will comment briefly on the other pairs offered in the table. Synthesis/analysis have their obvious implications given what has gone before. But there are also examples where the inverse analysis/synthesis pair might lead to additional conclusions if the reader wishes to pursue them. The cost/resource requirements pair is suggested by SFM association with budgeting and resource requirement prediction models. Actually, the mention of a "process" like budgeting arising out of the association of costs with resource requirements leads to the further association of costing with budgeting. The game seems to be taking a little different turn. Certainly, it seems the pair of processes, program review/program development is inferred by STM/SFM on the basis of the nature of information which may support these processes.

The foregoing illustrations, observations and suggestions were offered because we feel the development of the model, following the somewhat ordered process outlined, enhances one's understanding of the relationships among important variables. Playing the duality game as illustrated has the serious purpose of seeking common threads in the methodology of institutional research and, hence, glimpses of the theory. The game challenges our perception and understanding of what we think of as familiar ideas, yet the answer to the question (for example) what is the dual characteristic of "outcomes" and what is the significance of that mutual relationship may prove to be practical beyond the obvious mental exercise. Thus, in a sense, what we have proposed above is a question generator. We believe it to be a systematic provoker of the sorts of questions which might suggest a basis for extensions to the methodology.

CAMPUS APPLICATIONS OF THE MODEL

In this section, we present some actual uses of the STM software in our office. Since these applications are very much dependent on our "circumstances", they may not be readily transferable for other institutions. Nonetheless, these problems did arise at our institution and the STM software proved essential to their solution given those circumstances.

Part-Time Students

The University is reconsidering its policy on teaching in the Spring/Summer sessions. Currently, professors are paid an additional stipend for teaching in these sessions, and the responsibility for organizing the offerings and arranging for instruction rests with the Faculty of Continuing Education. The proposals would incorporate the teaching of Spring/Summer courses into the regular teaching load, thus eliminating the stipends and essentially leaving the responsibility for Spring/Summer courses to the teaching departments. The proposal, if implemented, would have considerable impact on the organization of the University, on individual professors and on resources required by academic departments. The Faculty of Continuing Education indicated a need to look at the significance of these organizational changes on planning, scheduling and advising on part-time programs. The Faculty requested information from the Office of Institutional Research on the number of Spring/Summer session students who study primarily on a part-time basis and who would typically consider themselves part-time rather than full-time students.

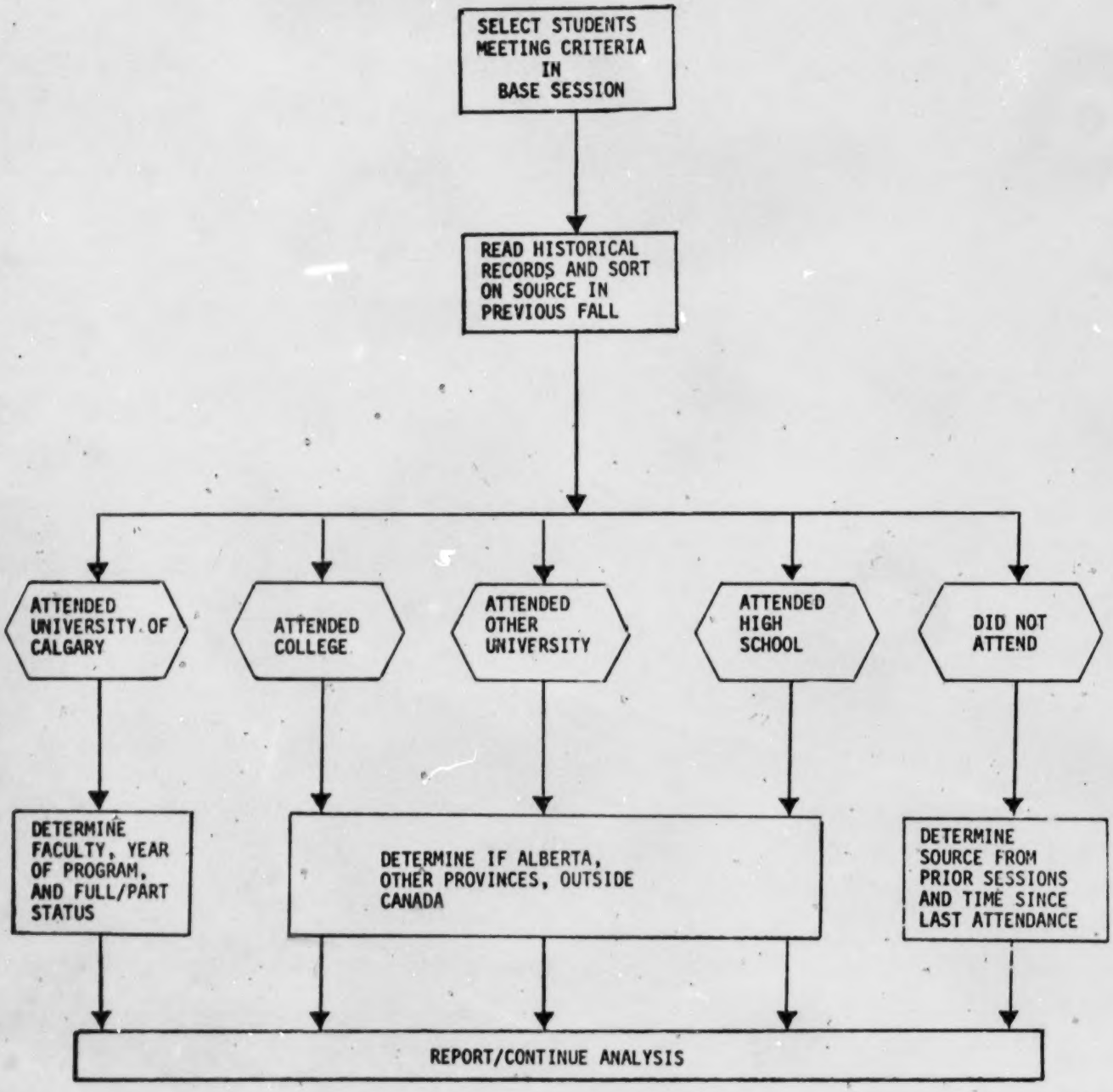
On our campus, identification of part-time students in any particular session is straightforward because the number of courses taken in a session is the determinant of part-time status. However, the University has no indicator for the student who is pursuing a program solely or mostly on a part-time basis. Hence, we had to develop a credible description of a part-

time student which was operationally practical given our data base and information systems. Since our interest was in Spring/Summer students, we arrived at a definition of a part-time student as one who is taking a course in the current session and who has not been a full-time student on this campus in any specified past sessions. It would have required substantial computer programming to identify directly each student over several years, and the programming time alone would have precluded responding to the request. The STM was used to trace back Spring/Summer students to prior sessions, thus allowing us to identify those students who could be considered primarily part-time.

The STM process is illustrated in Figure 2. Individual student records are picked from the student data base if the student meets the selection criteria in the base session. These records form the traceback file. In the case of this example, the traceback file would contain the records of those students who took at least one course in the current Spring/Summer session. Next, STM scans the students' historical records and sorts students into categories in accordance with whether they attended The University of Calgary or not in a specific previous session of interest. Since the traceback file contains the complete records of the selected students, each student in a category may be analyzed on the basis of student status and characteristics in a session(s) of interest. In the case of the example, it would be significant to know for the selected students the number of students who were part-time and the number who were full-time in the previous Fall term. Information OIR provided to the Faculty of Continuing Education indicates that about 40% of the Spring/Summer students appear to be studying on a part-time basis throughout the year. We also distributed the students

Figure 2

STUDENT TRACEBACK MODEL PROCESS DIAGRAM


SELECT STUDENTS MEETING CRITERIA IN BASE SESSION
READ HISTORICAL RECORDS AND SORT ON SOURCE IN PREVIOUS FALL
ATTENDED UNIVERSITY OF CALGARY
ATTENDED COLLEGE
ATTENDED OTHER UNIVERSITY
ATTENDED HIGH SCHOOL
DID NOT ATTEND
DETERMINE FACULTY, YEAR OF PROGRAM, AND FULL/PART STATUS
DETERMINE IF ALBERTA, OTHER PROVINCES, OUTSIDE CANADA
DETERMINE SOURCE FROM PRIOR SESSIONS AND TIME SINCE LAST ATTENDANCE
REPORT/CONTINUE ANALYSIS

by Faculty of registration and year of student academic program. We could as easily have added further breakdowns by grade point average, high school averages, citizenship, age, sex, and so on.

A sample output which can be generated from the STM "report" function noted in Figure 2, is illustrated in Figure 3. The "continued analysis" function on the STM process diagram indicates that the records of students selected by the STM may be input to other programs and, hence, be subject to further analysis or form part of a wider analysis.

ICLM Shaping for Program Planning

The next example demonstrates how we used the STM to estimate resource implications of proposed changes to student academic programs. The Faculty of Engineering proposed two new academic programs to replace the current four-year program, specifically, a three-year baccalaureate program and a five-year professional program. The Faculty requested the Office of Institutional Research to estimate academic FTE staff that would be required if the new student academic programs were introduced.[2] Appropriate ICLM's for each transitionary year were required for new and continuing students. Continuing students are those Engineering students caught in mid-program by the changes and, hence, have the option of continuing in the old program or choosing one of the new programs.

The ICLM's for the baccalaureate and professional programs were generated initially based on descriptions (required courses, optional courses, credit hours by level and instruction type) of the new program plans provided by the Faculty. Next, the initial ICLM's were adjusted to reflect expected differences between the courses students would be required to take, and those

Figure 3

SAMPLE OUTPUT FROM MODEL

STUDENTS ATTENDING THE UNIVERSITY OF CALGARY PREVIOUS SESSION

FACULTY	YEAR OF PROGRAM 1ST YEAR	2ND YEAR	3RD YEAR	4TH YEAR	OTHER	TOTAL
FULL-TIME						
Education	-	-	-	-	-	-
Engineering	-	-	-	-	-	-
.						
.						
TOTAL UNIVERSITY FULL-TIME	-	-	-	-	-	-
PART-TIME						
Education	-	-	-	-	-	-
Engineering	-	-	-	-	-	-
.						
.						
TOTAL UNIVERSITY PART-TIME	-	-	-	-	-	-

STUDENTS ATTENDING OTHER INSTITUTIONS PREVIOUS SESSION

ATTENDING UNIVERSITIES		ATTENDING COLLEGES		ATTENDING HIGH SCHOOL	
University of Alberta	-	Lethbridge	-	Calgary Public	-
University of Lethbridge	-	Medicine Hat	-	Calgary Separate	-
.		.		.	
.		.		.	
TOTAL ALBERTA		TOTAL ALBERTA	-	TOTAL ALBERTA	-
University of British Columbia	-	British Columbia	-	British Columbia	-
University of Saskatchewan	-	Saskatchewan	-	Saskatchewan	-
.		.		.	
.		.		.	
TOTAL CANADA	-	TOTAL CANADA	-	TOTAL CANADA	-
OTHER COUNTRIES	-	OTHER COUNTRIES	-	OTHER COUNTRIES	-
GRAND TOTAL	-	GRAND TOTAL	-	GRAND TOTAL	-

STUDENTS NOT ATTENDING INSTITUTIONS PREVIOUS SESSION

	SESSIONS SINCE LAST ATTENDANCE 1-2	3-4	5-8	>10	TOTAL
UNIVERSITIES					
University of Calgary	-	-	-	-	-
University of Alberta	-	-	-	-	-
.					
.					
COLLEGES					
Lethbridge Community College	-	-	-	-	-
Mount Royal College	-	-	-	-	-
.					
.					
HIGH SCHOOLS					
Calgary Public Schools	-	-	-	-	-
Calgary Separate Schools	-	-	-	-	-
.					
.					
GRAND TOTAL	-	-	-	-	-

they would likely take. This adjustment was made by drawing inferences from an experiential "realization ratio matrix" which records how actual course selection differs from that deduced on the basis of program course requirements alone. The traceback model read historical student records to select students who could be considered an appropriate sample of those not taking the courses required by the calendar for their particular year of program (e.g., students repeating the year totally, or those continuing in the same year of program but taking subsequent courses). This selection resulted in a file which could be accessed by a variety of retrieval programs to obtain additional information on possible reasons for the irregularities in their programs (e.g., particularly high failure rates in specific courses taken by students from non-English speaking countries). These data, the realization ratios, were used to adjust ICLM values.

The traceback model also assisted in the separation of the students into two groups--those expected to move to new programs, and those expected to remain with the old program--by indicating the historical course backgrounds of the continuing students. The ICLM for those continuing students remaining on the old program was adjusted to conform more accurately with known courses required by those students. The ICLM's for those students moving to new programs were generated essentially in the same manner as that described previously, i.e., based on descriptions of the new programs provided by the Faculty, and adjusted by realization ratios. Additional adjustments were made on the basis of course requirements which the transferring students would be required to make up in the new program. The revised ICLM's for both the new and the old program students were then used in analysis of the departmental resource implications for the Faculty. The Faculty was provided with estimates

of staff requirements which would ultimately be required to support the proposed programs, along with estimates for each year in which the current and proposed program would be taught concurrently.

CONCLUSION

We are pretty much persuaded by Joe L. Saupe's elegant conjecture that the defining substance of institutional research is its methodology. This essay tends to provide a perspective on the methodology of the problem-solving institutional researcher who must consider that methodology to include a wide spectrum of how-to's; how to anticipate significant issues in higher education, how to estimate the practical impact of these on his or her institution, how to develop the tools to cope with these problems, how to solve the problems and how to present the solutions so that they influence decisions. Institutional research is a practical activity and, hence, examples of the methodology are instructive and the context within which it operates is important. Yet, we suggest, if the defining substance of institutional research is its methodology, then institutional research methodology itself deserves more attention.

FOOTNOTES

[1]We use the word "dual" loosely. It conveys the essence of the notions which we need in this study of methodology. Later, precise analysis may suggest a more apt and correct name.

[2]The Office of Institutional Research supplies staff entitlement estimates annually to the University Budget Committee.